What is claimed is:

1. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, the first lens and the second lens are respectively made of a material having a specific gravity of 2.0 or less and the objective lens satisfies the following conditional formula:

$$NA \geqq 0.70,$$

where NA: a predetermined image side numerical aperture necessary for recording and/or reproducing of the optical information recording medium.

2. The objective lens of claim 1, wherein the following conditional formula is satisfied:

$$NA \geqq 0.80.$$

3. The objective lens of claim 1, wherein the first lens and the second lens are made of a plastic.

4. The objective lens of claim 1, wherein at least two surfaces are an aspherical surface among three surfaces.

5. The objective lens of claim 1, wherein the following conditional formula is satisfied:

$$1.1 \leqq f1/f2 \leqq 3.3$$

where f1: a focal length (mm) of the first lens, and f2: a focal length (mm) of the second lens.

6. The objective lens of claim 5, wherein the following conditional formula is satisfied:

$$1.2 \leqq f1/f2 \leqq 3.3$$

7. The objective lens of claim 1, wherein the following conditional formula is satisfied:

$$0.3 \leqq (r2 + r1)/(r2 - r1) \leqq 3.2$$

where r1 : a paraxial radius of curvature (mm) of the first surface, and r2 : a paraxial radius of curvature (mm) of the second surface.

8. The objective lens of claim 1, wherein the following conditional formula is satisfied:

$$-0.15 < (X1' - X3')/((NA)^4 \cdot f) < 0.10$$

where X1' and X3' are represented by the following formula,

$X1' = X1 \cdot (N1 - 1)^3 / f1$

$X3' = X3 \cdot (N2 - 1)^3 / f2$

where X1: a distance (mm) in the optical axis direction between a plane which is perpendicular to the optical axis and contacts the vertex of a surface of the first lens at a side closest to a light source and a surface of the first lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the first lens at which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

X3: a distance (mm) in the optical axis between a plane which is perpendicular to the optical axis direction and contacts the vertex of a surface of the second lens at a side closest to a light source and a surface of the second lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the second lens at which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the

optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

f: a focal length (mm) of the total system of the objective lens;

N1: a refractive index of the first lens at a used wavelength; and

N2: a refractive index of the second lens at a used wavelength.

9. The objective lens of claim 8, wherein the following conditional formula is satisfied:

$$-0.08 < (X1' - X3')/((NA)^4 \cdot f) < 0.05$$

10. The objective lens of claim 1, wherein when a using wave length is 500 nm or less, the objective lens is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

11. The objective lens of claim 10, wherein the objective lens is made of a material whose internal transmittance at a thickness of 3 mm is not smaller than 95%.

12. The objective lens of claim 1, wherein a thickness of the transparent substrate of the optical information recording medium onto which the recording and/or reproducing of the information is conducted, is not larger than 0.6 mm.

13. The objective lens of claim 1, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.5%.

14. The objective lens of claim 13, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.1%.

15. The objective lens of claim 1, wherein the first lens and the second lens are respectively made of a material whose specific gravity is not larger than 2.0, and ring-shaped diffractive structure is provided at least on one surface, and the following conditional formula is satisfied.

$$\nu di \leqq 65.0$$

where νdi: Abbe's number (i = 1 and 2) of d line of the i-th lens.

16. The objective lens of claim 15, wherein when the diffraction order of a diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure of the i-th surface is ni-th, the number of the ring-shaped zones of the i-th surface is Mi, the minimum value of the ring-shaped zone interval is Pi (mm), a focal length of the whole objective lens system is f (mm), and a using wavelength is λ (mm), the following conditional formula is satisfied.

$$0.04 \leqq \lambda \cdot f \cdot \Sigma\ (ni/(Mi \cdot Pi^2)) \leqq 0.3$$

17. The objective lens of claim 15, wherein an amount of n-th order diffracted ray generated at the diffractive structure is larger than the amount of any other ordered diffracted rays, and in order to record and /or reproduce the information onto the optical information recording medium, the n-th ordered diffracted ray generated at the diffractive structure is converged onto the information recording plane of the optical information recording medium, where n is an integer except for 0, $\pm$ 1.

18. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, the first lens and the second lens are respectively made of a plastic and the objective lens satisfies the following conditional formula:

$$0.09 \leqq WD/f \leqq 0.24$$

where WD: a working distance (mm) of the objective lens and f: a focal length (mm) of the objective lens.

19. The objective lens of claim 18, wherein the following conditional formula is satisfied:

$$NA \geqq 0.70,$$

where NA: a predetermined image side numerical aperture necessary for recording and/or reproducing of the optical information recording medium.

20. The objective lens of claim 19, wherein the following conditional formula is satisfied:

$$NA \geqq 0.80.$$

21. The objective lens of claim 18, wherein at least two surfaces are aspherical surfaces among a first surface to a third surface.

22. The objective lens of claim 18, wherein the following conditional formula is satisfied:

$$1.1 \leqq f1/f2 \leqq 5.0$$

where fi: the focal length (mm) of the i-th lens (i = 1 or 2).

23. The objective lens of claim 22, wherein the following conditional formula is satisfied:

$$1.2 \leqq f1/f2 \leqq 5.0$$

24. The objective lens of claim 18, wherein the following conditional formula is satisfied:

$$0.3 \leqq (r2 + r1)/(r2 - r1) \leqq 4.8$$

where, ri : a paraxial radius of curvature (mm) of the i-th surface (i = 1 or 2).

25. The objective lens of claim 18, wherein the following conditional formula is satisfied:

$$-0.15 < (X1' - X3')/((NA)^4 \cdot f) < 0.10$$

where X1′ and X3′ are represented by the following formula,

$X1' = X1 \cdot (N1 - 1)^3/f1$

$X3' = X3 \cdot (N2 - 1)^3/f2$

where X1: a distance (mm) in the optical axis direction between a plane which is perpendicular to the optical axis and contacts the vertex of a surface of the first lens at a side closest to a light source and a surface of the first lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the first lens at which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

X3: a distance (mm) in the optical axis direction between a plane which is perpendicular to the optical axis and contacts the vertex of a surface of the second lens at a side closest to a light source and a surface of the second lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the second lens at

which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

f: a focal length of the total system of the objective lens;

N1: a refractive index of the first lens at a used wavelength; and

N2: a refractive index of the second lens at a used wavelength.

26. The objective lens of claim 25, wherein the following conditional formula is satisfied:

$$-0.08 < (X1' - X3')/((NA)^4 \cdot f) < 0.05$$

27. The objective lens of claim 18, wherein when a using wave length is 500 nm or less, the objective lens is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

28. The objective lens of claim 27, wherein the objective lens is made of a material whose internal transmittance at a thickness of 3 mm is not smaller than 90%.

29. The objective lens of claim 18, wherein a thickness of the transparent substrate of the optical information recording medium onto which the recording and/or reproducing of the information is conducted, is not larger than 0.6 mm.

30. The objective lens of claim 18, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.5%.

31. The objective lens of claim 30, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.1%.

32. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the following conditional formula is satisfied:

$NA \geqq 0.70$

$0.05 < WD/ENP < 0.25$

where NA: a predetermined numerical aperture necessary for conducting the recording and/or reproducing of the optical information recording medium,

WD: a working distance (mm) of the objective lens,

ENP: a diameter of an entrance pupil (mm) of the objective lens.

33. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$NA \geqq 0.80.$

34. The objective lens of claim 32, wherein ring-shaped diffractive structure is provided on at least one surface of the objective lens.

35. The objective lens of claim 32, wherein the first lens and the second lens are respectively made of a plastic and the following conditional formula is satisfied:

$0.05 \leqq WD/ENP \leqq 0.15$

36. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$$\nu di \leqq 65.0$$

where νdi : Abbe's number of d line of the i-th lens (i = 1 or 2).

37. The objective lens of claim 32, wherein when a reference wavelength is λ (mm), a focal length of the whole objective lens system is f (mm), the diffraction order of a diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure of the i-th surface is ni-th, the number of the ring-shaped zones of the i-th surface is Mi, and the minimum value of the ring-shaped zone interval is Pi (mm), the following conditional formula is satisfied.

$$0.04 \leqq \lambda \cdot f \cdot \Sigma\, (ni/(Mi \cdot Pi^2)) \leqq 0.60$$

38. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$$0.01 \leqq PD/PT \leqq 0.20$$

where PD: a power (mm^{-1}) of only a diffractive structure defined by $P_D = \sum_{i=1}^{N}(-2 \cdot ni \cdot b_{2i})$ when the diffractive

surface is named the first diffractive surface, the second diffractive surface, ... the n-th diffractive surface in the order from the light source side and an optical path difference added to a transmitting wave surface by the diffractive structure formed on the i-th diffractive surface is expressed by an optical path difference function defined by $\Phi_{bi} = n_i \cdot (b_{2i} \cdot h^2 + b_{4i} \cdot h^4 + b_{6i} \cdot h^6 + \ldots)$ (herein, n_i is the diffraction order number of the diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure formed on the i-th diffractive surface, h_i is a height (mm) from the optical axis, b_{2i}, b_{4i}, b_{6i}, ..., are respectively coefficients of optical path difference function of second order, fourth order, sixth order, ...), and

PT : a power (mm^{-1}) of the total system of the objective lens in which the refractive lens and the diffractive structure are combined.

39. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$$|\Delta\ fB \cdot NA^2| \leqq 0.25$$

where Δ fB: a change (μm) of a paraxial focal point of the objective lens when the wavelength of the light source is changed by + 1 nm.

40. The objective lens of claim 32, wherein when diffractive action as a diffractive lens and refractive action as a refractive lens are combined, the objective lens has an axial chromatic aberration characteristic which changes in a direction in which a back focus is shortened when a wavelength of the light source shifts to a long wavelength side, and the following formula is satisfied:

$$-1 < \Delta CA / \Delta SA < 0$$

where ΔCA: the change amount (mm) of the paraxial focal point for the change of the wavelength, and

ΔSA: the change amount (mm) of the spherical aberration of the marginal ray for the change of the wavelength.

41. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$$0.2 \leqq |(Ph/Pf) - 2| \leqq 5.0$$

where Pf: a diffractive ring-shaped zone interval (mm) at a predetermined image side numerical aperture necessary for conducting the recording and/or reproducing

onto the optical information recording medium, Ph: a diffractive ring-shaped zone interval (mm) at a numerical aperture of 1/2 of the predetermined image side numerical aperture necessary for conducting the recording and/or reproducing onto the optical information recording medium.

42. The objective lens of claim 32, wherein an amount of ni-th order diffracted ray generated at the diffractive structure formed on the i-th surface is larger than the amount of any other ordered diffracted rays, and in order to record and /or reproduce the information onto the optical information recording medium, the ni-th ordered diffracted ray generated in the diffractive structure is converged onto the information recording plane of the optical information recording medium, where n is an integer except for 0, ± 1.

43. The objective lens of claim 32, wherein the following conditional formula is satisfied:

$$1.5 \leqq f1/f2 \leqq 5.0$$

$$0.3 \leqq (r2 + r1)/(r2 - r1) \leqq 6.0$$

where fi: the focal length (mm) of the i-th lens (i = 1 or 2), and

ri : a paraxial radius (mm) of curvature of the i-th surface (i = 1 or 2).

44. The objective lens of claim 32, wherein the following formula is satisfied:

$$-0.15 < (X1' - X3')/((NA)^4 \cdot f) < 0.10$$

where X1' and X3' are represented by the following formula,

$$X1' = X1 \cdot (N1 - 1)^3/f1$$

$$X3' = X3 \cdot (N2 - 1)^3/f2$$

where X1: a distance (mm) in the optical axis direction between a plane which is perpendicular to the optical axis and contacts the vertex of a surface of the first lens at a side closest to a light source and a surface of the first lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the first lens at which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

X3: a distance (mm) in the optical axis direction between a plane which is perpendicular to the optical axis and contacts the vertex of a surface of the second lens at a side closest to a light source and a surface of the second

lens at a side closest to the light source at an outermost periphery of the effective diameter (the outermost periphery corresponds to a position on a surface of the second lens at which a marginal ray of the above NA comes to be incident), when the distance is measured in a direction toward to the optical information recording medium, the distance is singed with plus (+), and when the distance is measured in a direction toward to the light source, the distance is singed with minus (-);

f: a focal length (mm) of the total system of the objective lens;

N1: a refractive index of the first lens at a used wavelength; and

N2: a refractive index of the second lens at a used wavelength.

45. The objective lens of claim 44, wherein the following conditional formula is satisfied:

$$-0.10 < (X1' - X3')/((NA)^4 \cdot f) < 0.04$$

46. The objective lens of claim 32, wherein when a using wave length is 500 nm or less, the objective lens is made of a material whose internal transmittance at a thickness of 3

mm in a region of the using wavelength is not smaller than 85%.

47. The objective lens of claim 46, wherein the objective lens is made of a material whose internal transmittance at a thickness of 3 mm is not smaller than 90%.

48. The objective lens of claim 32, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.5%.

49. The objective lens of claim 48, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.1%.

50. The objective lens of claim 32, wherein the objective lens satisfies the following conditional formula.

$$0.07 \leqq WD/ENP \leqq 0.20$$

51. The objective lens of claim 50, wherein at least two surfaces are an aspherical surface among three surfaces.

52. The objective lens of claim 50, wherein the following conditional formula is satisfied:

$1.1 \leqq f1/f2 \leqq 5.0$

where fi: the focal length (mm) of the i-th lens (i = 1 or 2).

53. The objective lens of claim 52, wherein the following conditional formula is satisfied:

$1.2 \leqq f1/f2 \leqq 5.0$

54. The objective lens of claim 1, wherein the following conditional formula is satisfied:

$0.3 \leqq (r2 + r1)/(r2 - r1) \leqq 4.8$

where ri : a paraxial radius of curvature (mm) of the i-th lens (i = 1 or 2).

55. The objective lens of claim 50, wherein a thickness of the transparent substrate of the optical information recording medium onto which the recording and/or reproducing of the information is conducted, is not larger than 0.6 mm.

56. An objective lens for use in an information recording reproducing optical pick-up apparatus which comprises a light converging optical system including the objective lens to converge a light flux from light sources having different

wavelengths onto a recording plane of an optical information recording medium and a light receiving element for detecting a reflected light beam from the recording plane, and which can record and/or reproduce information onto a plurality of optical information recording media whose transparent substrate thickness are different, comprising:

a first lens having a positive refractive power; and a second lens having a positive refractive power, the first lens and the second lens aligned in this order from a light source side of the objective lens,

wherein the first lens and the second lens are respectively made of a material whose specific gravity is not larger than 2.0, and the objective lens has ring-shaped diffractive structure on at least one surface thereof, and

wherein under the following condition that:

among the plurality of optical information recording media whose transparent substrates have respectively a different thickness, the thickness of transparent substrates of two arbitrary optical information recording media are $t1$ and $t2$ ($t1 < t2$),

when the information is recorded or reproduced onto the optical information recording medium having the thickness of the transparent substrate of $t1$, the used wavelength is $\lambda 1$, and when the information is recorded or reproduced onto the

optical information recording medium having the thickness of the transparent substrate of t2, the used wavelength is $\lambda 2$ ($\lambda 1 < \lambda 2$), and

a predetermined image side numerical aperture necessary for conducting the recording or reproducing onto the optical information recording medium with the thickness of the transparent substrate of t1 by the light flux having the wavelength $\lambda 1$, is NA1, and a predetermined image side numerical aperture necessary for conducting the recording or reproducing onto the optical information recording medium with the thickness of the transparent substrate of t2 by the light flux having the wavelength $\lambda 2$, is NA2 ($NA1 \geqq NA2$);

a wave front aberration is 0.07 $\lambda 1$ rms or less for a combination of a wavelength $\lambda 1$, a thickness t1 of a transparent substrate and an image side numerical aperture NA1, and a wave front aberration is 0.07 $\lambda 2$ rms or less for a combination of a wavelength $\lambda 2$, a thickness t2 of another transparent substrate and an image side numerical aperture NA2.

57. The objective lens of claim 56, wherein the first lens and the second lens are respectively made of a plastic.

58. The objective lens of claim 56, wherein the wave front aberration is 0.07 λ2 rms or less for a combination of the wavelength λ2, the thickness t2 of a transparent substrate and the image side numerical aperture NA2, and the wave front aberration is 0.07 λ2 rms or more for a combination of the wavelength λ2, the thickness t2 of a transparent substrate and the image side numerical aperture NA1.

59. The objective lens of claim 56, wherein the wave front aberration is 0.07 λ1 rms or less for a combination of an object point at the predetermine position, the wavelength λ1, the thickness t1 of a transparent substrate and the image side numerical aperture NA1, and the wave front aberration is 0.07 λ2 rms or less for a combination of an object point located with a distance optically equal to the predetermined position, the wavelength λ2, the thickness t2 of a transparent substrate and the image side numerical aperture NA2.

60. The objective lens of claim 56, wherein the wave front aberration is 0.07 λ1 rms or less for a combination of an object point at the predetermine position, the wavelength λ1,

the thickness t1 of a transparent substrate and the image side numerical aperture NA1, and the wave front aberration is 0.07 $\lambda 2$ rms or less for a combination of an object point located with a distance optically unequal to the predetermined position, the wavelength $\lambda 2$, the thickness t2 of a transparent substrate and the image side numerical aperture NA2.

61. The objective lens of claim 56, wherein at least two surfaces are an aspherical surface among three surfaces.

62. The objective lens of claim 56, wherein the following conditional formula is satisfied:

$$0.4 \leqq |(Ph/Pf) - 2| \leqq 25$$

where Pf: a diffractive ring-shaped zone interval (mm) at a predetermined image side numerical aperture NA1 necessary for conducting the recording and/or reproducing onto the optical information recording medium having a transparent substrate having a thickness t1, and

Ph: a diffractive ring-shaped zone interval (mm) at a numerical aperture of 1/2 of NA1.

63. The objective lens of claim 56, wherein the following conditional formula is satisfied:

$1.3 \leqq f1/f2 \leqq 4.0$

$0.3 \leqq (r2 + r1)/(r2- r1) \leqq 3.2$

where fi: the focal length (mm) of the i-th lens (i = 1 or 2)(when the i-th lens has a diffractive structure, a focal length of the entire system of the i-th lens in which the refractive lens and the diffractive structure are combined), and

ri : a paraxial radius (mm) of curvature of the i-th surface (i = 1 or 2).

64. The objective lens of claim 56, wherein the following conditional formula is satisfied:

$t1 \leqq 0.6$ mm

$t2 \geqq 0.6$ mm

$\lambda 1 \leqq 500$ nm

600 nm $\leqq \lambda 2 \leqq 800$ nm

$NA1 \geqq 0.65$

$NA2 \leqq 0.65$

65. The objective lens of claim 56, wherein the objective lens is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

66. The objective lens of claim 56, wherein the objective lens is made of the material whose saturation water absorption is not larger than 0.5%.

67. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the objective lens has ring-shaped diffractive structure on at least one surface thereof, and

wherein the following conditional formula is satisfied:

$$0.05 \leqq PD/PT \leqq 0.20$$

where PD: a power (mm^{-1}) of only a diffractive structure defined by $P_D = \sum_{i=1}^{N} (-2 \cdot ni \cdot b_{2i})$ when the diffractive surface is named the first diffractive surface, the second diffractive surface, ... the n-th diffractive surface in the

order from the light source side and an optical path difference added to a transmitting wave surface by the diffractive structure formed on the i-th diffractive surface is expressed by an optical path difference function defined by $\Phi b = n_i \cdot (b_{2i} \cdot h^2 + b_{4i} \cdot h^4 + b_{6i} \cdot h^6 + \ldots)$ (herein, n_i is the diffraction order number of the diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure formed on the i-th diffractive surface, h_i is a height (mm) from the optical axis), b_{2i}, b_{4i}, b_{6i}, ..., are respectively coefficients of optical path difference function of second order, fourth order, sixth order, ...,) and

PT : a power (mm^{-1}) of the whole system of the objective lens in which the refractive lens and the diffractive structure are combined.

68. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the objective lens has ring-shaped diffractive structure on at least one surface thereof, and

wherein when a diffractive action as a diffractive lens and a refractive action as a refractive lens are combined, the objective lens has an axial chromatic aberration characteristic which changes in a direction in which a back focus is shortened when a wavelength of the light source shifts to a long wavelength side, and the following formula is satisfied:

$$-1 < \Delta CA / \Delta SA < 0$$

where ΔCA: the change amount (mm) of a paraxial focal point for the change of the wavelength, and ΔSA: the change amount (mm) of the spherical aberration of the marginal ray for the change of the wavelength.

69. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the objective lens has ring-shaped diffractive structure on at least one surface thereof, and

wherein the following formula is satisfied:

$$1.0 \leqq (r2 + r1)/(r2 - r1) \leqq 6.0$$

where ri : a paraxial radius (mm) of curvature of the i-th surface (i = 1 or 2).

70. The objective lens of claim 69, wherein the following conditional formula is satisfied:

$$1.5 \leqq f1/f2 \leqq 5.0$$

where fi: a focal length (mm) of the i-th lens (i = 1 or 2).

71. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the objective lens has a ring-shaped diffractive structure on at least one surface thereof, and

wherein when a using wave length is 500 nm or less, the objective lens is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

72. An objective lens for recording and/or reproducing an optical information recording medium, comprising:

a first lens having a positive refractive power; and

a second lens having a positive refractive power;

wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the objective lens has ring-shaped diffractive structure on at least one surface including the second surface thereof, and

wherein the following formula is satisfied:

$1.0 < (r2 + r1)/(r2 - r1)$

where ri : a paraxial radius (mm) of curvature of the i-the surface (i = 1 or 2).

73. A light converging optical system for recording and/or reproducing information, comprising:

a light source;

an objective lens to converge a light flux emitted from the light source onto an information recording plane through a transparent substrate of an optical information recording medium, wherein the objective lens comprises a first lens having a positive refractive power and a second lens having a positive refractive power, the first lens and the second lens are aligned in this order from a light source side of the objective lens, the first lens and the second lens are respectively made of a material having a specific gravity of

2.0 or less and the objective lens satisfies the following conditional formula:

$$NA \geqq 0.70,$$

where NA: a predetermined image side numerical aperture necessary for recording and/or reproducing of the optical information recording medium; and

a spherical aberration correcting element provided between the light source and the objective lens and to correct a variation of a spherical aberration generated on each optical surface of the light converging optical system.

74. The light converging optical system of claim 73, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a change in the temperature and/or the humidity.

75. The light converging optical system of claim 73, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated on each optical surface of the light converging optical system due to a slight change in the thickness of the transparent substrate of the information recording medium.

76. The light converging optical system of claim 73, wherein the optical information recording medium comprises a plurality of recording layers so as to clamp the transparent substrate at the same light flux incident side, the objective lens is displaceable in the optical axis direction in order to converge light beam onto each recording layer, and the spherical aberration correcting element corrects a variation of a spherical aberration due to a difference in the thickness of transparent substrate from the light flux incident side to each recording layer.

77. The light converging optical system of claim 73, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a slight change in the wavelength of the light source.

78. The light converging optical system of claim 73, wherein the spherical aberration correcting element has an adjustable refractive index distribution.

79. The light converging optical system of claim 73, wherein the spherical aberration correcting element includes at least one positive lens and at least one negative lens and

comprises a structure of a beam expander to make an almost parallel incident light flux to emit in form of an almost parallel light flux, and wherein at least one lens of the spherical aberration correcting element is structured as a displaceable element which can be displaced along the optical axis direction.

80. The light converging optical system of claim 79, wherein the positive lens and the negative lens satisfy the following conditional formula:

$$\nu dP > \nu dN$$

Where νdP : an average value of Abbe's number of d line of a positive lens included in the spherical aberration correcting element, and

νdN: an average value of Abbe's number of d line of a negative lens included in the spherical aberration correcting element.

81. The light converging optical system of claim 80, wherein the positive lens and the negative lens satisfy the following conditional formula:

$$\nu dP > 55.0$$

$$\nu dN < 35.0$$

82. The light converging optical system of claim 81, wherein a difference $\Delta\nu$ between the average value of Abbe's number of d line of a positive lens included in the spherical aberration correcting element and the average value of Abbe's number of d line of a negative lens included in the spherical aberration correcting element satisfy the following formula:

$$30 \leqq \Delta\nu \leqq 50$$, and

wherein the displaceable element is made of a material having a specific gravity of 2.0 or less.

83. The light converging optical system of claim 79, wherein Abbe's number of all positive lenses included in the spherical aberration correcting element is 70.0 or less, or Abbe's number of all negative lenses included in the spherical aberration correcting element is 40.0 or more, and at least one of the positive lens and the negative lens comprises at least one diffractive surface having ring-shaped diffractive structure.

84. The light converging optical system of claim 83, wherein the displaceable element is made of a material having a specific gravity of 2.0 or less.

85. The light converging optical system of claim 83, wherein the spherical aberration correcting element is made of a plastic.

86. The light converging optical system of claim 83, wherein the spherical aberration correcting element is made of a material whose saturation water absorption is not larger than 0.5%.

87. The light converging optical system of claim 83, wherein an amount of n-th ordered diffracted ray generated at the diffractive structure is larger than the amount of any other ordered diffracted rays, and in order to record and /or reproduce the information onto the optical information recording medium, the n-th ordered diffracted ray generated at the diffractive structure is converged onto the information recording plane of the optical information recording medium, where n is an integer except for 0, ± 1.

88. The light converging optical system of claim 79, wherein when a using wave length is 500 nm or less, the spherical aberration correcting element is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

89. The light converging optical system of claim 79, wherein the spherical aberration correcting element comprises one positive lens and one negative lens and has at least one aspherical surface, and at least one lens is structured as a displaceable element which can be displaced along the optical axis direction.

90. The light converging optical system of claim 89, wherein the displaceable element is displaced along the optical axis direction in such a manner that, when the spherical aberration of the light converging optical system is varied in the over corrected direction, an interval between the positive lens and the negative lens is decreased by a predetermined amount in comparison with that before the spherical aberration is varied, and when the spherical aberration of the light converging optical system is varied in the under corrected direction, an interval between the positive lens and the negative lens is increased by a predetermined amount in comparison with that before the spherical aberration is varied.

91. The light converging optical system of claim 73, wherein the following conditional formula is satisfied:

$t \leqq 0.6$ mm

$\lambda \leqq 500$ nm

where t: the thickness of the transparent substrate of the optical information recording medium, and

λ: the wavelength of the light source.

92. The light converging optical system of claim 73, wherein an axial chromatic aberration of a composite system of the spherical aberration correcting element and the objective lens satisfy the following conditional formula:

$|\delta fB \cdot NA^2| \leqq 0.25\ \mu m$

where δfB : a change (μm) of a paraxial focal point of the composite system when the wavelength of the light source changes by + 1 nm.

93. A light converging optical system for recording and/or reproducing information, comprising:

a light source;

an objective lens to converge a light flux emitted from the light source onto an information recording plane through a transparent substrate of an optical information recording medium,

a coupling lens provided between the light source and the objective lens, wherein an axial chromatic aberration of the coupling lens is corrected excessively such that a focal length is made longer for a wavelength shorter by 10 nm than the used wavelength;

wherein a change of the spherical aberration generated at each optical surface of the light converging optical system is corrected by displacing the coupling lens in the optical axis direction.

94. The light converging optical system of claim 93, wherein a change of the spherical aberration is corrected by displacing the coupling lens in the optical axis direction in accordance with a slight difference in the wavelength of the light source.

95. The light converging optical system of claim 93, wherein a change of the spherical aberration is corrected by displacing the coupling lens in the optical axis direction in accordance with a change of the temperature and the humidity.

96. The light converging optical system of claim 93, wherein a change of the spherical aberration is corrected by displacing the coupling lens in the optical axis direction in

accordance with a slight difference in the thickness of the transparent substrate of the optical information recording medium.

97. The light converging optical system of claim 93, wherein the optical information recording medium comprises a plurality of recording layers so as to clamp the transparent substrate at the same light flux incident side, the objective lens is displaceable in the optical axis direction in order to converge light beam onto each recording layer, and a variation of a spherical aberration due to a difference in the thickness of transparent substrate from the light flux incident side to each recording layer is corrected by displacing the coupling lens in the optical axis direction.

98. The light converging optical system of claim 93, wherein the coupling lens comprises one lens group and the coupling lens is displaced along the optical axis direction in such a manner that, when the spherical aberration of the light converging optical system is varied in the over corrected direction, an interval between the light source and the coupling lens is decreased by a predetermined amount in comparison with that before the spherical aberration is varied, and when the spherical aberration of the light

converging optical system is varied in the under corrected direction, an interval between the light source and the coupling lens is increased by a predetermined amount in comparison with that before the spherical aberration is varied.

99. The light converging optical system of claim 93, wherein the objective lens comprises a first lens having a positive refractive power and a second lens having a positive refractive power, the first lens and the second lens are aligned in this order from a light source side of the objective lens, the first lens and the second lens are respectively made of a material having a specific gravity of 2.0 or less and the objective lens satisfies the following conditional formula:

$$NA \geqq 0.70,$$

where NA: a predetermined image side numerical aperture necessary for recording and/or reproducing of the optical information recording medium.

100. The light converging optical system of claim 93, wherein the following conditional formula is satisfied:

$$NA \geqq 0.70$$

$t \leqq 0.6$ mm

$\lambda \leqq 500$ nm

where NA: a predetermined image side numerical aperture of the objective lens necessary for recording and/or reproducing onto the optical information recording medium,

t: the thickness of the transparent substrate of the optical information recording medium, and

λ: the wavelength of the light source.

101. The light converging optical system of claim 93, wherein an axial chromatic aberration of a composite system of the spherical aberration correcting element and the objective lens satisfy the following conditional formula:

$|\delta fB \cdot NA^2| \leqq 0.25$ μm

where δfB : a change (μm) of a paraxial focal point of the composite system when the wavelength of the light source changes by + 1 nm.

102. A light converging optical system which comprises a light source having different wavelength, an objective lens to converge a light flux from the light source onto a recording surface of an optical information recording medium, and which can record and/or reproduce information onto a

plurality of optical information recording media whose transparent substrate thickness are different, comprising:

a first lens having a positive refractive power; and a second lens having a positive refractive power, the first lens and the second lens aligned in this order from a light source side of the objective lens,

wherein the first lens and the second lens are respectively made of a material whose specific gravity is not larger than 2.0, and the objective lens has ring-shaped diffractive structure on at least one surface thereof, and

wherein under the following condition that:

among the plurality of different wavelength, the wavelength of two arbitrary wavelength are $\lambda 1$, $\lambda 2$ ($\lambda 1 < \lambda 2$),

among the plurality of optical information recording media whose transparent substrates have respectively a different thickness, the thickness of transparent substrates of two arbitrary optical information recording media are t1 and t2 ($t1 < t2$), and

a predetermined image side numerical aperture necessary for conducting the recording or reproducing onto the optical information recording medium with the thickness of the transparent substrate of t1 by the light flux having the wavelength $\lambda 1$, is NA1, and a predetermined image side numerical aperture necessary for conducting the recording or

reproducing onto the optical information recording medium with the thickness of the transparent substrate of t2 by the light flux having the wavelength $\lambda 2$, is NA2 (NA1 $\geqq$ NA2);

a wave front aberration is 0.07 $\lambda 1$ rms or less for a combination of the wavelength $\lambda 1$, the thickness t1 of a transparent substrate and the image side numerical aperture NA1, and a wave front aberration is 0.07 $\lambda 2$ rms or less for a combination of the wavelength $\lambda 2$, the thickness t2 of another transparent substrate and the image side numerical aperture NA2; and

the light converging optical system further comprising a spherical aberration correcting element provided between the light source and the objective lens so as to correct a change of the spherical aberration generated at each optical surface of the light converging optical system.

103. The light converging optical system of claim 102, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a change in the temperature and/or the humidity.

104. The light converging optical system of claim 102, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a slight change in the thickness of the transparent substrate of the information recording medium.

105. The light converging optical system of claim 102, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a slight change in the wavelength of the light source.

106. The light converging optical system of claim 102, wherein for the plurality of optical information recording medium having a different thickness of a transparent substrate from each other, the spherical aberration correcting element changes a converging angle of the light flux incident on the objective lens in accordance with the respective different thickness of the transparent substrate.

107. The light converging optical system of claim 102, wherein the spherical aberration correcting element has an adjustable refractive index distribution.

108. The light converging optical system of claim 102, wherein the spherical aberration correcting element includes at least one positive lens and at least one negative lens and comprises a structure of a beam expander to make an almost parallel incident light flux to emit in form of an almost parallel light flux, and wherein at least one lens of the positive lens and the negative lens is structured as a displaceable element which can be displaced along the optical axis direction.

109. The light converging optical system of claim 108, wherein the positive lens and the negative lens satisfy the following conditional formula:

$$\nu dP > \nu dN$$

where νdP : an average value of Abbe's number of d line of a positive lens included in the spherical aberration correcting element, and

νdN: an average value of Abbe's number of d line of a negative lens included in the spherical aberration correcting element.

110. The light converging optical system of claim 109, wherein the positive lens and the negative lens satisfy the following conditional formula:

$$\nu dP > 55.0$$

$$\nu dN < 35.0$$

111. The light converging optical system of claim 110, wherein a difference $\Delta\nu$ between the average value of Abbe's number of d line of a positive lens included in the spherical aberration correcting element and the average value of Abbe's number of d line of a negative lens included in the spherical aberration correcting element satisfy the following formula:

$$30 \leqq \Delta\nu \leqq 50$$, and

wherein the displaceable element is made of a material having a specific gravity of 2.0 or less.

112. The light converging optical system of claim 108, wherein Abbe's number of all positive lenses included in the spherical aberration correcting element is 70.0 or less, or Abbe's number of all negative lenses included in the spherical aberration correcting element is 40.0 or more, and the light converging optical system comprises at least one diffractive surface having ring-shaped diffractive structure.

113. The light converging optical system of claim 112, wherein the displaceable element is made of a material having a specific gravity of 2.0 or less.

114. The light converging optical system of claim 112, wherein the spherical aberration correcting element is made of a plastic.

115. The light converging optical system of claim 114, wherein the spherical aberration correcting element is made of a material whose saturation water absorption is not larger than 0.5%.

116. The light converging optical system of claim 108, wherein the spherical aberration correcting element is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

117. The light converging optical system of claim 108, wherein the spherical aberration correcting element comprises one positive lens and one negative lens and has at least one aspherical surface, and at least one lens is structured as a

displaceable element which can be displaced along the optical axis direction.

118. The light converging optical system of claim 117, wherein the displaceable element is displaced along the optical axis direction in such a manner that, when the spherical aberration of the light converging optical system is varied in the over corrected direction, an interval between the positive lens and the negative lens is decreased by a predetermined amount in comparison with that before the spherical aberration is varied, and when the spherical aberration of the light converging optical system is varied in the under corrected direction, an interval between the positive lens and the negative lens is increased by a predetermined amount in comparison with that before the spherical aberration is varied.

119. The light converging optical system of claim 117, wherein among the plurality of optical information recording media whose transparent substrates have respectively a different thickness, when the thickness of transparent substrates of two arbitrary optical information recording media are t1 and t2 ($t1 < t2$),

the displaceable element is displaced along the optical axis direction in such a manner that, an interval between the positive lens and the negative lens is increased by a predetermined amount at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t1 of the transparent substrate than at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t2 of the transparent substrate, and an interval between the positive lens and the negative lens is decreased by a predetermined amount at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t2 of the transparent substrate than at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t1 of the transparent substrate.

120. The light converging optical system of claim 102, wherein the spherical aberration correcting element is a coupling lens to change a divergent angle of a divergent light flux emitted from the light source and the coupling lens is a displaceable element capable of displacing along the optical axis direction.

121. The light converging optical system of claim 120, wherein the spherical aberration correcting element is a single lens whose at least one surface is made a diffractive surface having ring-shaped diffractive structure.

122. The light converging optical system of claim 121, wherein the spherical aberration correcting element has at least one aspheric surface whose radius of curvature becomes larger with distance from the optical axis and has at least one diffractive surface having a ring-shaped diffractive structure.

123. The light converging optical system of claim 122, wherein a surface of the spherical aberration correcting element at the light source side is a diffractive surface which has a spherical shape macroscopically and a surface of the spherical aberration correcting element at another side far from the light source is a aspherical surface whose radius of curvature becomes larger with distance from the optical axis.

124. The light converging optical system of claim 120, wherein the spherical aberration correcting element has a

structure of two elements in one group in which a positive lens having a relatively larger Abbe's number and a negative lens having a relatively smaller Abbe's number are cemented.

125. The light converging optical system of claim 124, wherein the positive lens and the negative lens satisfy the following conditional formula:

$\nu dP > 55.0$

$\nu dN < 35.0$

where νdP : an Abbe's number of d line of a positive lens, and

νdN: an Abbe's number of d line of a negative lens, and

the light converging optical system comprises at least one aspherical surface.

126. The light converging optical system of claim 120, wherein the spherical aberration correcting element is made of a material having a specific gravity of 2.0 or less.

127. The light converging optical system of claim 126, wherein the spherical aberration correcting element is made of a plastic.

128. The light converging optical system of claim 127, wherein the spherical aberration correcting element is made of a material whose saturation water absorption is not larger than 0.5%.

129. The light converging optical system of claim 120, wherein the spherical aberration correcting element is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.

130. The light converging optical system of claim 120, wherein the spherical aberration correcting element consists of one lens group and the spherical aberration correcting element is displaced along the optical axis direction in such a manner that, when the spherical aberration of the light converging optical system is varied in the over corrected direction, an interval for the objective lens is increased by a predetermined amount in comparison with that before the spherical aberration is varied, and when the spherical aberration of the light converging optical system is varied in the under corrected direction, an interval for the objective lens is decreased by a predetermined amount in

comparison with that before the spherical aberration is varied.

131. The light converging optical system of claim 120, wherein among the plurality of optical information recording media whose transparent substrates have respectively a different thickness, when the thickness of transparent substrates of two arbitrary optical information recording media are t1 and t2 (t1 < t2),

the spherical aberration correcting element consists of one lens group and the spherical aberration correcting element is displaced along the optical axis direction in such a manner that, an interval for the objective lens is decreased by a predetermined amount at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t1 of the transparent substrate than at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t2 of the transparent substrate, and an interval for the objective lens is increased by a predetermined amount at the time of conducting recording or reproducing information for the optical information recording medium having the thickness t2 of the transparent substrate than at the time of conducting

recording or reproducing information for the optical information recording medium having the thickness t1 of the transparent substrate.

132. The light converging optical system of claim 102, wherein the following conditional formula is satisfied:

$t1 \leqq 0.6$ mm

$t2 \geqq 0.6$ mm

$\lambda 1 \leqq 500$ nm

600 nm $\leqq \lambda 2 \leqq$ 800 nm

$NA1 \geqq 0.65$

$NA2 \leqq 0.65$

133. The light converging optical system of claim 102, wherein an axial chromatic aberration of a composite system of the spherical aberration correcting element and the objective lens satisfy the following conditional formula:

$|\delta fBi \cdot NAi^2| \leqq 0.25\ \mu m$

where δfBi : a change (μm) of a paraxial focal point of the composite system when the wavelength λi of the light source changes by + 1 nm (i = 1 or 2).

134. A light converging optical system for use in an optical pick-up apparatus for recording and/or reproducing of an optical information recording medium, comprising:

a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source; and

an objective lens to light converge the light flux having passed through the coupling lens onto an information recording plane through a transparent substrate of the optical information recording medium, wherein ring-shaped diffractive structure is formed on at least one optical surface of an optical element constituting the light converging optical system, and the coupling lens comprises a two lens group, and at least one lens group constituting the coupling lens is moved along an optical axis direction such that a variation of the spherical aberration generated at each optical surface of the light converging optical system is corrected.

135. The light converging optical system of claim 134, wherein the light source emits a light flux having a wavelength not larger than 600 nm, and an axial chromatic aberration generated by a refractive action of each refractive surface in the light converging optical system and

an axial chromatic aberration generated by the diffractive structure are cancelled.

136. The light converging optical system of claim 135, wherein the axial chromatic aberration of a composite system composed of the coupling lens, the optical element on which the diffractive structure is provided, and the objective lens, satisfies the following conditional formula:

$|\Delta fB \cdot NA^2| \leqq 0.25\ \mu m$

where NA: a predetermined image side numerical aperture of the objective lens necessary for conducting the recording and/or reproducing onto the optical information recording medium, and

ΔfB: a change (μm) of the paraxial focal point of the composite system when the wavelength of the light source is changed by + 1 nm.

137. The light converging optical system of claim 134, wherein the predetermined image side numerical aperture of the objective lens necessary for conducting the recording and/or reproducing onto the optical information recording medium is not smaller than 0.65, and the thickness of the transparent substrate of the optical information recording medium is not larger than 0.6 mm.

138. The light converging optical system of claim 134, wherein among the lens groups constituting the coupling lens, the lens group which can be moved along the optical axis, has a positive refractive power and satisfies the following conditional formula:

$$4 \leqq f_{CP}/f_{OBJ} \leqq 17$$

where f_{CP} : the focal length (mm) of the lens group having the positive refractive power which can be moved along the optical axis, and

f_{OBJ}: the focal length (mm) of the objective lens.

139. The light converging optical system of claim 134, wherein among the lens groups constituting the coupling lens, the lens group which can be moved along the optical axis, has the negative refractive power and satisfies the following conditional formula:

$$-20 \leqq f_{CN}/f_{OBJ} \leqq -3$$

where f_{CN} : the focal length (mm) of the lens group having the negative refractive power which can be moved along the optical axis, and

f_{OBJ}: the focal length (mm) of the objective lens.

140. The light converging optical system of claim 134, wherein the lens group which can be moved along the optical axis direction among the lens groups constituting the coupling lens is made of a material whose specific gravity is not larger than 2.0.

141. The light converging optical system of claim 134, wherein at least one lens group constituting the coupling lens is moved along the optical axis direction such that a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a variation of the wavelength of the light source is corrected.

142. The light converging optical system of claim 134, wherein the objective lens includes at least one lens made of a plastic material and at least one lens group constituting the coupling lens is moved along the optical axis such that a variation of a spherical aberration generated at each optical surface of the light converging optical system due to the temperature or humidity change is corrected.

143. The light converging optical system of claim 134, wherein at least one lens group constituting the coupling lens is moved along the optical axis such that a variation of

a spherical aberration generated due to the variation of a thickness of the transparent substrate of the information recording medium is corrected.

144. The light converging optical system of claim 134, wherein the optical information recording medium has a structure in which a plurality of transparent substrates and information recording layers are alternately laminated in an order at the same light flux incident side, and wherein the objective lens is moved along the optical axis so that a focusing is conducted for recording and/or reproducing the information onto each information recording layer, and at least one lens group constituting the coupling lens is moved along the optical axis direction such that a variation of a spherical aberration generated due to a difference of the thickness of the transparent substrate from the light flux incident surface to each information recording layer is corrected.

145. The light converging optical system of claim 134, wherein when the spherical aberration of the light converging optical system is varied in the over corrected direction, the coupling lens decreases an interval between two lens groups constituting the coupling lens by a predetermined amount in

comparison with that before the spherical aberration is varied, and when the spherical aberration of the light converging optical system is varied in the under corrected direction, the coupling lens increases an interval between two lens groups constituting the coupling lens by a predetermined amount in comparison with that before the spherical aberration is varied.

146. A light converging optical system for recording and/or reproducing of the optical information recording medium, comprising:

a light source to emit a light flux having a wavelength not larger than 600 nm;

a coupling lens to change a divergent angle of a divergent light flux emitted from the light source; and

an objective lens to converge the light flux through the coupling lens onto an information recording plane of the optical information recording medium,

wherein the coupling lens has at least one diffractive surface made having ring-shaped diffractive structure, and an axial chromatic aberration of the coupling lens is corrected excessively such that a focal length becomes longer for a wavelength shorter by 10 nm than the reference wavelength of

the light source, and the coupling lens satisfies the following formula:

$$0.05 \leqq NA \leqq 0.50$$

where, NA: the numerical aperture of the coupling lens, and

wherein an axial chromatic aberration generated in the objective lens due to a wavelength change when the light source generates the wavelength change not larger than ± 10 nm and an axial chromatic aberration generated in the diffractive structure of the coupling lens are cancelled.

147. The light converging optical system of claim 146, wherein a composite system of the coupling lens and the objective lens has an axial chromatic aberration characteristic which is changed to a direction to which a back focus is shortened when the wavelength of the light source shifts on a longer wavelength side, and when a changed amount of a spherical aberration of a marginal ray for a change of the wavelength is ΔSA and a changed amount of a paraxial focal point is ΔCA, the following conditional formula is satisfied:

$$-1 < \Delta CA/\Delta SA < 0.$$

148. The light converging optical system of claim 146, wherein it is assumed that a change of a paraxial focal point of a composite system of the coupling lens and the objective lens is ΔfB (μm) when a wavelength of the light source is changed by + 10 nm and a predetermined image side numerical aperture of the objective lens necessary for recording or reproducing the optical information recording medium is the NA_{OBJ}, an axial chromatic aberration of the composite system satisfies the following conditional formula:

$$|\Delta fB \cdot (NA_{OBJ})^2| \leqq 2.5\ \mu m.$$

149. A light converging optical system for recording and/or reproducing of information of an optical information recording medium, comprising:

an objective lens for converging a light flux emitted from a light source onto an information recording plane of the optical information recording medium, the objective lens including a first lens having a positive refractive power and a second lens having a positive refractive power, wherein the first lens and the second lens are aligned in this order from a light source side of the objective lens, the objective lens having ring-shaped diffractive structure on at least one surface thereof and satisfying the following conditional formula:

$NA \geqq 0.70$

$0.05 < WD/ENP < 0.25$

where NA: a predetermined numerical aperture necessary for conducting the recording and/or reproducing of the optical information recording medium,

WD: a working distance (mm) of the objective lens,

ENP: a diameter of an entrance pupil (mm) of the objective lens; and

the light converging optical system further comprising an spherical aberration correcting element to correct a variation of a spherical aberration generated at each optical surface of the light converging optical system between the light source and the objective lens.

150. The light converging optical system of claim 149, wherein the spherical aberration correcting element corrects a variation of a spherical aberration generated at each optical surface of the light converging optical system due to a slight change in the wavelength of the light source.

151. The light converging optical system of claim 149, wherein the light converging optical system comprises at least one optical element made of a plastic and the spherical aberration correcting element corrects a variation of a

spherical aberration generated at each optical surface of the light converging optical system due to a change in the temperature and/or the humidity.

152. The light converging optical system of claim 149, wherein the spherical aberration correcting element corrects a variation of the spherical aberration generated at each optical surface of the light converging optical system due to a slight change in the thickness of the transparent substrate of the information recording medium.

153. The light converging optical system of claim 149, wherein the spherical aberration correcting element has an adjustable refractive index distribution.

154. The light converging optical system of claim 149, wherein the spherical aberration correcting element comprises an optical element capable of changing a divergent degree of an emitted light flux by displacing along the optical axis.

155. The light converging optical system of claim 154, wherein the optical element is made of a material having a specific gravity of 2.0 or less.

156. The light converging optical system of claim 154, wherein the optical element is made of a plastic.

157. The light converging optical system of claim 149, wherein the light converging optical system can record and or reproduce information for an optical information recording medium having a structure in which a plurality of transparent substrates and information recording layers are alternately laminated in an order at the same light flux incident side, and wherein the objective lens is moved along the optical axis so that a focusing is conducted for recording and/or reproducing the information onto each information recording layer, and the spherical aberration correcting element corrects a variation of a spherical aberration generated due to a difference of the thickness of the transparent substrate from the light flux incident surface to each information recording layer.

158. A coupling lens which changes a divergent angle of a divergent light flux emitted from a light source for recording and/or reproducing of an optical information recording medium and makes the light flux to enter into an objective lens, comprising:

the coupling lens having an axial chromatic aberration excessively corrected so that a focal length becomes longer for a wavelength which is 10 nm shorter than a using wavelength.

159. The coupling lens of claim 158, wherein the coupling lens is a single lens which has at least one aspherical surface whose radius of curvature becomes larger with distance from the optical axis and has at least one surface shaped in a diffractive surface structured by a plurality of coaxial ring-shaped steps.

160. The coupling lens of claim 159, wherein a surface at the light source side is a diffractive surface which has a spherical shape macroscopically and a surface at another side far from the light source is a aspherical surface whose radius of curvature becomes larger with distance from the optical axis.

161. The coupling lens of claim 159, wherein when n is an integer showing an order of a diffracted ray having the maximum amount among diffracted rays generated at the diffractive surface, M is the number of the ring-shaped zones of the diffractive surface, P (mm) is the minimum value of

the ring-shaped zone interval, and fc (mm) is a focal length of the total system of the coupling lens, the following conditional formula is satisfied:

$$0.20 \leqq n \cdot fc \cdot \lambda/(M \cdot P^2) \leqq 1.0.$$

162. The coupling lens of claim 159, wherein an amount of n-th ordered diffracted ray generated at the diffractive structure is larger than the amount of any other ordered diffracted rays, and in order to record and /or reproduce the information onto the optical information recording medium, the n-th ordered diffracted ray generated at the diffractive structure is converged onto the information recording plane of the optical information recording medium, where n is an integer except for 0, ± 1.

163. The coupling lens of claim 158, wherein the coupling lens has the structure of two elements in one group in which a positive lens having a relatively larger Abbe's number and a negative lens having a relatively smaller Abbe's number are cemented.

164. The coupling lens of claim 163, wherein the coupling lens has at least one an aspherical surface and satisfies the following conditional formula:

ν dP > 55.0

ν dN < 35.0

where ν dP : an Abbe's number of d line of a positive lens, and

ν dN: an Abbe's number of d line of a negative lens.

165. The coupling lens of claim 158, wherein the coupling lens is made of a material having a specific gravity of 2.0 or less.

166. The coupling lens of claim 165, wherein the coupling lens is made of a plastic material.

167. The coupling lens of claim 166, wherein the coupling lens is made of a plastic material whose saturation water absorption is not larger than 0.5%.

168. A coupling lens to change a divergent angle of a divergent light flux emitted from a light source and to make the divergent light flux incident on an objective lens, comprising:

at least one diffractive surface having ring-shaped diffractive structure,

wherein an axial chromatic aberration is excessively corrected so that a focal length is made longer for a wavelength shorter by 10 nm than a reference wavelength of the light source and the coupling lens satisfies the following conditional formula

$0.05 \leqq NA \leqq 0.50$

where, NA: the numerical aperture of the coupling lens.

169. The coupling lens of claim 168, wherein the following conditional formula is satisfied:

$0.3 < P_D/P_{TOTAL} < 3.0$ (75)

where PD: a power (mm^{-1}) of only a diffractive structure defined by $P_D = \sum_{i=1}^{N} (-2 \cdot ni \cdot b_{2i})$ when the diffractive structure formed on the i-th surface of the coupling lens is expressed by an optical path difference function defined by the following expression: $\Phi_{bi} = n_i \cdot (b_{2i} \cdot h_i^2 + b_{4i} \cdot h_i^4 + b_{6i} \cdot h_i^6 + \ldots)$ (A) (herein, n_i is the diffraction order number of the diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure, h_i is a height (mm) from the optical axis), b_{2i}, b_{4i}, b_{6i}, ..., are respectively coefficients of optical path difference function of second order, fourth order, sixth order, ...,) and

P_{TOTAL}: a power (mm^{-1}) of the total system of the coupling lens in which a refractive power and a diffractive power by the diffractive structure are combined.

170. The coupling lens of claim 168, wherein when a reference wavelength is λ (mm), a focal length of the whole objective lens system is f (mm), the diffraction order of a diffracted ray having the maximum amount among diffracted rays generated at the diffractive structure of the i-th surface is ni-th, the number of the ring-shaped zones of the i-th surface is Mi, and the minimum value of the ring-shaped zone interval is Pi (mm), the following conditional formula is satisfied.

$$0.1 \leqq \lambda \cdot f \cdot \Sigma \left(ni/(Mi \cdot Pi^2)\right) \leqq 3.0$$

171. The coupling lens of claim 168, wherein when a reference wavelength is λ (mm), a minute change of the wavelength from the reference wavelength is $\Delta\lambda$ (mm), a focal length at the reference wavelength is f (mm), and a change of the focal length when the wavelength of the light source is changed by $\Delta\lambda$ (mm) from the reference wavelength is Δf (mm), the following conditional formula is satisfied.

$$-0.12 \leqq (\Delta f / f) \cdot NA \cdot (\lambda/\Delta\lambda) \leqq -0.01$$

172. The coupling lens of claim 168, wherein coupling lens comprises two or more surfaces made in a diffractive surface having a ring-shaped diffractive structure.

173. The coupling lens of claim 168, wherein a stepped difference in an optical axis direction of each ring-shaped diffractive zone of at least one diffractive surface among the diffractive surfaces is determined such that an amount of the n-th ordered diffracted ray is larger than that of any other ordered diffracted rays generated at the diffractive surface, where n is an integer except 0 and ±1.

174. The coupling lens of claim 168, wherein at least one diffractive surface including a surface at the light source side is made in a diffractive surface having a ring-shaped diffractive structure.

175. The coupling lens of claim 168, wherein at least one surface is made in an aspherical surface, the following conditional formula is satisfied:

$$0.10 \leqq NA \leqq 0.50$$

176. The coupling lens of claim 168, wherein the coupling lens is made of a plastic material.

177. The coupling lens of claim 168, wherein one optical surface of the coupling lens is the plane surface on which ring-shaped diffractive structure is formed and another optical surface opposite to the plane surface is a spherical surface and/or an aspherical surface.

178. The coupling lens of claim 177, wherein diffractive structure formed on the plane surface is blaze structure.

179. The coupling lens of claim 177, wherein when a using wavelength is λ (mm), the minimum value of pitches of the ring-shaped zones in the effective diameter of the diffractive structure formed on the plane surface is P (mm), the following formula is satisfied:

$$P/\lambda < 30 .$$

180. The coupling lens of claim 179, wherein the following formula is satisfied:

$$P/\lambda < 20 .$$

181. The coupling lens of claim 177, wherein the optical surface shaped in the spherical surface and/or the aspherical surface is refractive surface.

182. The coupling lens of claim 177, wherein the optical surface shaped in the spherical surface or the aspherical surface is provided with a ring-shaped diffractive structure.

183. The coupling lens of claim 182, wherein when a using wavelength is λ (mm), the minimum value of pitches of the ring-shaped zones in the effective diameter of the diffractive structure formed on the optical surface shaped in the spherical surface and/or the aspherical surface is P (mm), the following formula is satisfied:

$$P/\lambda > 20 .$$

184. An optical pick-up apparatus, comprising:

a light converging optical system including a light source, and objective lens for converging a light flux from the light source onto a recording plane of an optical information recording medium, and a spherical aberration correcting element arranged between the light source and the objective lens;

a photo detector for detecting a reflected light flux from the recording plane;

a first drive apparatus for driving the objective lens for converging the light flux onto the recording plane according to the detection results of the photo detector, and

a second drive apparatus for driving the spherical aberration correcting element according to the detection results of the photo detector,

wherein the objective lens comprises a first lens having a positive refractive power and a second lens having a positive refractive power; the first lens and the second lens are aligned in this order from a light source side of the objective lens, and the first lens and the second lens are respectively made of a material having a specific gravity of 2.0 or less and the objective lens satisfies the following conditional formula:

$$NA \geqq 0.70,$$

where NA: a predetermined image side numerical aperture necessary for recording and/or reproducing of the optical information recording medium.

185. An optical pick-up apparatus for recording and/or reproducing information for a plurality of optical information recording medium different in a thickness of a transparent substrate, comprising:

a light converging optical system including light sources different in a wavelength, an objective lens to converge a light flux from the light source onto a recording plane of an optical information recording medium and a spherical aberration correcting element provided between the light sources and the objective lens;

a photo detector for detecting a reflected light beam from the recording plane;

a first drive apparatus for driving the objective lens for converging the light flux onto the recording plane according the detection results of the photo detector;

a second drive apparatus for driving the spherical aberration correcting element according the detection results of the photo detector,

the light converging optical system comprising a first lens having a positive refractive power; and a second lens having a positive refractive power, the first lens and the second lens aligned in this order from a light source side of the objective lens, the first lens and the second lens respectively made of a material whose specific gravity is not larger than 2.0 and the light converging optical system having ring-shaped diffractive structure on at least one surface thereof, and

wherein under the following condition that:

among the plurality of different wavelength, the wavelength of two arbitrary wavelength are $\lambda 1$, $\lambda 2$ ($\lambda 1 < \lambda 2$),

among the plurality of optical information recording media whose transparent substrates have respectively a different thickness, the thickness of transparent substrates of two arbitrary optical information recording media are t1 and t2 ($t1 < t2$), and

a predetermined image side numerical aperture necessary for conducting the recording or reproducing onto the optical information recording medium with the thickness of the transparent substrate of t1 by the light flux having the wavelength $\lambda 1$, is NA1, and a predetermined image side numerical aperture necessary for conducting the recording or reproducing onto the optical information recording medium with the thickness of the transparent substrate of t2 by the light flux having the wavelength $\lambda 2$, is NA2 ($NA1 \geqq NA2$);

a wave front aberration is 0.07 $\lambda 1$ rms or less for a combination of the wavelength $\lambda 1$, the thickness t1 of a transparent substrate and the image side numerical aperture NA1, and a wave front aberration is 0.07 $\lambda 2$ rms or less for a combination of the wavelength $\lambda 2$, the thickness t2 of another transparent substrate and the image side numerical aperture NA2; and

the spherical aberration correcting element provided between the light source and the objective lens so as to correct the variation of the spherical aberration generated at each optical surface of the light converging optical system.

186. An optical pick-up apparatus for recording and/or reproducing information for an information recording plane of an optical information recording medium, comprising:

a light source;

a light converging optical system including a coupling lens which consists of two lens groups to change a divergent angle of a divergent light flux emitted from the light source and an objective lens to converge the light flux having passed through the coupling lens onto a recording plane through a transparent substrate of an optical information recording medium;

a photo detector for detecting a reflected light beam from the recording plane;

a first drive apparatus for driving the objective lens in an optical axis direction or a direction perpendicular to the optical axis for converging the light flux onto the recording plane;

a second drive apparatus for driving at least one lens group of the coupling lens in the optical axis direction; and

ring-shaped diffractive structure formed on at least one optical surface of optical element constituting the the light converging optical system;

wherein the second driving apparatus displaces at least one lens group constituting the coupling lens in the optical axis direction so that a variation of a spherical aberration generated at each optical surface of the light converging optical system.

187. An optical pick-up apparatus for recording and/or reproducing information for an information recording surface of an optical information recording medium, comprising:

a photo detecor;

a light source to emit a light flux having a wavelength not larger than 600 nm; and

a light converging optical system including a coupling lens to change a divergent angle of a divergent light flux emitted from the light source and an objective lens to converge the light flux through the coupling lens onto an information recording plane of the optical information recording medium,

wherein the coupling lens has at least one diffractive surface having ring-shaped diffractive structure, and an axial chromatic aberration of the coupling lens is corrected excessively such that a focal length becomes longer for a wavelength shorter by 10 nm than the reference wavelength of the light source, and the coupling lens satisfies the following formula:

$$0.05 \leqq NA \leqq 0.50$$

where, NA: the numerical aperture of the coupling lens, and

wherein an axial chromatic aberration generated in the objective lens due to a wavelength change when the light source generates the wavelength change not larger than ± 10 nm and an axial chromatic aberration generated in the diffractive structure of the coupling lens are cancelled.

188. An optical pick-up apparatus for recording and/or reproducing information for an information recording plane of an optical information recording medium by detecting a reflected light flux from the information recording plane, comprising:

a first photo detector to detect a tracking error and/or a focusing error of the objective lens by detecting

the reflected light flux from the information recording plane;

a first driving device to drive the objective lens so as to reduce the tracking error and/or the focusing error in accordance with a detection result of the first photo detector;

a second photo detector to detect a variation of a spherical aberration generated at the light converging optical system by detecting the reflected light beam from the information recording plane;

a second driving device to drive the spherical aberration correcting element so as to reduce the variation of the spherical aberration in accordance with a detection results of the second photo detector;

wherein the objective lens comprises a first lens having a positive refractive power and a second lens having a positive refractive power, the first lens and the second lens are aligned in this order from a light source side of the objective lens, the objective lens has diffractive structure on at least one surface thereof, the objective lens is made of a material whose saturation water absorption is not larger than 0.5% and the following conditional formula is satisfied:

$NA \geqq 0.70$

$0.05 < WD/ENP < 0.25$

where NA: a predetermined numerical aperture necessary for conducting the recording and/or reproducing of the optical information recording medium,

WD: a working distance (mm) of the objective lens,

ENP: a diameter of an entrance pupil (mm) of the objective lens.

189. An audio and/or image recording apparatus and/or an audio and/or image reproducing apparatus on which the optical pick-up apparatus recited in claim 186 is mounted.

190. An audio and/or image recording apparatus and/or an audio and/or image reproducing apparatus on which the optical pick-up apparatus recited in claim 187 is mounted.

191. An audio and/or image recording apparatus and/or an audio and/or image reproducing apparatus on which the optical pick-up apparatus recited in claim 188 is mounted.

192. An audio and/or image recording apparatus and/or an audio and/or image reproducing apparatus on which the optical pick-up apparatus recited in claim 184 is mounted.

193. An audio and/or image recording apparatus and/or an audio and/or image reproducing apparatus on which the optical pick-up apparatus recited in claim 185 is mounted.

194. The light converging optical system of claim 93, wherein the spherical aberration correcting element is a single lens whose at least one surface is made a diffractive surface having ring-shaped diffractive structure.

195. The light converging optical system of claim 194, wherein the spherical aberration correcting element has at least one aspheric surface whose radius of curvature becomes larger with distance from the optical axis and has at least one diffractive surface having a ring-shaped diffractive structure.

196. The light converging optical system of claim 195, wherein a surface of the spherical aberration correcting element at the light source side is a diffractive surface which has a spherical shape macroscopically and a surface of the spherical aberration correcting element at another side far from the light source is a aspherical surface whose radius of curvature becomes larger with distance from the optical axis.

197. The light converging optical system of claim 93, wherein the spherical aberration correcting element has a structure of two elements in one group in which a positive lens having a relatively larger Abbe's number and a negative lens having a relatively smaller Abbe's number are cemented.

198. The light converging optical system of claim 197, wherein the positive lens and the negative lens satisfy the following conditional formula:

$\nu dP > 55.0$

$\nu dN < 35.0$

where νdP : an Abbe's number of d line of a positive lens, and

νdN: an Abbe's number of d line of a negative lens, and

the light converging optical system comprises at least one aspherical surface.

199. The light converging optical system of claim 193, wherein the spherical aberration correcting element is made of a material having a specific gravity of 2.0 or less.

200. The light converging optical system of claim 199, wherein the spherical aberration correcting element is made of a plastic.

201. The light converging optical system of claim 200, wherein the spherical aberration correcting element is made of a material whose saturation water absorption is not larger than 0.5%.

202. The light converging optical system of claim 93, wherein the spherical aberration correcting element is made of a material whose internal transmittance at a thickness of 3 mm in a region of the using wavelength is not smaller than 85%.